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SUBMARINE TELEPHONE CABLES AND INTERNATIONAL TELECOMMUNICATIONS

R. T. Nichols

The RAND Corporation
SANTA MONICA • CALIFORNIA

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PREFACE

The study described in this Memorandum was prepared as part of The RAND Corporation's program of self-sponsored research in the public interest. In addition to its work for the United States Air Force and other government agencies, the Corporation regularly sponsors, with its own funds, research projects in areas of importance to national security and public welfare. This research is considered to be fundamentally the responsibility of the individuals involved in the project, and the conclusions are not necessarily endorsed by the Corporation. Such studies are published in the hope that they may contribute to wider understanding of important national problems.

The present Memorandum is a brief descriptive study of the network of submarine telephone cables that, since the first transatlantic cable was completed in 1956, has been expanding rapidly in worldwide coverage and circuit capacity. The development of the cable systems is discussed together with their role in providing transoceanic telecommunications facilities and with the aim of analyzing the competition that a future communications satellite system may offer. The author is Russell T. Nichols of RAND's Economics Department. He wishes to acknowledge the assistance from many individuals in the American Telephone and Telegraph Company. Without their aid, this paper could not have been written.

This Memorandum is based to a considerable extent on earlier research undertaken by RAND for the National Aeronautics and Space Administration, and RAND is grateful to NASA for permission to draw on this previous work. The views here expressed should, of course, in no way be interpreted as reflecting the official opinion or policy of NASA or any of the other sponsors of RAND research.

SUMMARY

Laying submarine telephone cables is now one of the most rapidly growing industries in the world. Three cable-laying vessels have been or will be put into service in the six months from October 1962 to March 1963. New factories which will produce submarine telephone cable are being built in the United States, England, and Japan. A new factory which makes the type of repeaters now used on United States telephone cables has recently been completed. The value of the investment in long-distance submarine telephone cables was $210,000,000 at the end of 1962; during the next three years alone, that is, in 1963, 1964, and 1965, cables will be laid with a value of $400,000,000.

With allowance for a substantial growth in demand for overseas telecommunications services (but without allowance for the effect on volume of any future reductions in prices of such services), it appears that the present and projected telephone cable facilities will be adequate to meet demands on the North Atlantic route until 1965 and on other routes for a few more years.

CONTENTS

I. CAPACITY AND INVESTMENT IN SUBMARINE TELEPHONE CABLE SYSTEMS

Since the first transatlantic telephone cable was placed in 1956, with a capacity of 36 voice channels, the number and capacity of deep-water telephone cables has expanded rapidly. Appendix A gives a detailed chronology, which the interested reader should examine, because in the text of this Memorandum we give only a brief summary of the material to be found in this appendix and in the other two appendixes.

On the transatlantic route, from the United States and Canada to Europe, the number of voice channels on all submarine telephone cables increased from 36 at the end of 1956 to 176 at the end of 1962. By the end of 1965, the number of voice channels will have increased to 304.

On the first leg of the Pacific route, from the United States and Canada to Hawaii, the first cable was laid in 1957, with a voice channel capacity of 36. At the end of 1962, the voice channel capacity was 48. By the end of 1965, the voice channel capacity will have increased to 256. There are now no completed cables that run from Hawaii to the Far East. By the end of 1965, there will be a cable with 80 voice channels from Hawaii to New Zealand, Australia, New Guinea, North Borneo, Hong Kong, and Singapore. In addition, there will be a cable with 128 voice channels from Hawaii to Guam, with branches to Japan and the Philippines.

In the Caribbean, the first long-distance submarine telephone cable was placed to Puerto Rico in 1960, with a capacity of 48 voice channels. By the end of 1965, there will be two cables to the Virgin Islands and Puerto Rico, with a capacity of 176 voice channels; and in addition a cable to Jamaica and the Canal Zone, with a capacity of 128 voice channels. The United States will be connected with South America through two extensions of the Caribbean cables, each with a capacity of 80 voice channels: an extension of the Canal Zone cable will be placed to Colombia, and an extension of the Virgin Islands-Puerto Rico cable to Venezuela.

To complete this inventory, a cable was laid to Bermuda in 1962 with a capacity of 80 voice channels but initially equipped for 48 voice channels. There are also cables to Cuba, but these have been supplemented by tropospheric scatter systems; and there is a cable to Alaska, which has been supplemented by microwave systems.

Year by year, the capacity of submarine telephone cables that terminate in the United States or Canada, excluding the cables to Cuba and Alaska, is as follows:

End of Year	Voice Channels	Voice Trunks
1956	36	36
1957	72	72
1958	72	72
1959	108	108
1960	192	266
1961	252	400
1962	376	524
1963	712	860
1964	840	1136
1965	968	1338

Capacity in terms of voice channels is a minimum measure, appropriate to military use of the cable systems; capacity in terms of voice trunks is a measure appropriate to use of the cable systems for the ordinary purpose of carrying telephone calls. The voice trunk estimates for the years 1963-1965 are subject to a considerable margin of error. For a full discussion of the capacity of cable systems, see Appendix B. It should be noted that the term "voice channels" is frequently, perhaps typically, applied to what we call "voice trunks," as well as to what we call "voice channels."

The investment cost of these various cable systems will be on the order of $600,000,000 by the end of 1965. Of this total, about $220,000,000 was spent on cables completed before the end of 1962, and $400,000,000 will be spent on cables to be completed in the three years 1963-1965. Full details are given in Appendix C.

There are, of course, submarine telephone cables not terminating or not linked with cables terminating in the United States and Canada. From Great Britain, there are cable systems to all the Scandinavian

countries, to Iceland, Norway, Sweden, and Denmark. There are also cable systems from Great Britain to Germany, the Netherlands, and Belgium as well as the very short cable systems to France. Across the Mediterranean, there are cables from Sicily to North Africa, cables from Marseilles to Algiers, and probably others.

The British Commonwealth plans to complete a system linking Britain with the Far East by 1965. Links from Britain to Canada, across Canada by microwave, and from Canada to Hawaii, New Zealand, and Australia will be completed by the end of 1963. A Southeast Asia cable system, linking Australia, New Guinea, North Borneo, Singapore, Malaya, and Hong Kong is scheduled for completion in 1965.

The Japanese have plans for cable construction in the Far East, but we do not know the details.

II. ALTERNATIVES TO SUBMARINE TELEPHONE CABLES (OTHER THAN COMMUNICATIONS SATELLITES)

The most direct alternative to a submarine telephone cable system, for long-distance transmission, is a high frequency (HF) radio-telephone system. Before 1956, all of the American overseas telephone traffic, with the sole exception of traffic to Cuba, was carried by HF radio circuits.

HF radiotelephone circuits are becoming quite unimportant from the standpoint of traffic carried, although they continue to be very important for the purpose of reaching countries to which no cable service is provided. The HF systems on routes also served by cable have not been dismantled, to our knowledge. They carry a very small fraction of the revenue traffic--less than 5 per cent of the total, but they are used by operators and for standby purposes, to provide service when there are breaks in the cables.

Quantitatively, HF telephone circuits add little to the circuits provided and to be provided by cables. To Europe, AT&T now has 54 HF circuits, about half of which are available on any given day; by 1965, AT&T will have the use of about 360 voice trunks in the cables to Europe. To Bermuda, there are 10 HF circuits, in contrast to the 80 cable circuits. To Colombia and Ecuador, there are 9 HF circuits, in contrast to the 80 circuits that will be provided by cable (direct to Colombia, and then by overland microwave to Ecuador).

A sharp distinction must be made between HF radiotelephone circuits and circuits provided by tropospheric scatter systems. Unfortunately, the latter are sometimes classed with HF circuits under the heading "radiotelephone circuits," but they are entirely different. In contrast to HF circuits, which are subject to fading, distortion, and complete blackout, because of the vagaries of the ionosphere, tropospheric scatter circuits are much more dependable. Furthermore, they may be made to have very large capacities, sufficient to carry TV programs.

Tropospheric scatter circuits are used by AT&T, for commercial purposes, only for links of 300 miles and less. The first commercial

tropo system was that installed to Cuba, which went into service September 12, 1957, with a capacity of 36 voice channels together with a two-way capacity for carrying one TV program [BTM, Autumn 1957, pp. 43-44].* The only other important commercial use of tropospheric scatter by AT&T, of which we know, is in the provision of circuits to Nassau in the Bahamas.

For distances of 200 miles and less, then, tropospheric scatter circuits offer a more economical means of communication than do cable circuits.

In certain applications, submarine telephone cable systems offer an acceptable alternative to overland cables and to overland microwave systems. In general, overland systems are far cheaper: we have reckoned the cost per unit of output to be more than ten times greater for submarine cable than for overland microwave [RM-2709, p. 22]. However, there are routes where the submarine cable has been chosen in preference to overland systems. One case in point is that of the Seattle-Ketchikan route, where a submarine cable was installed although the link might have been served by overland microwave. Another case is that of the cable to the Panama Canal Zone, to which there is obviously a continuous land connection. In these cases, rough terrain, political factors, and security factors probably accounted for the choice of the cable system. To Alaska, a microwave system has now been installed.

A very interesting choice of route is that for the 1963 transatlantic cable, TAT-3. The route selected runs from New Jersey directly to England, a distance of 3500 nautical miles, undersea all the way. An alternative route is the great circle route followed by the first two transatlantic cables: overland from New Jersey to Nova Scotia, a 325-mile cable link from Nova Scotia to Newfoundland, a 2000-mile deepwater cable link from Newfoundland to Scotland, and a second overland link from Scotland to England. Thus, the route chosen for TAT-3 by AT&T and the British Post Office represents the

*Sources cited in the text by short-title in brackets [ ] are given in full on p. 35.

substitution of about 1400 nautical miles of expensive cable for a shorter mileage of very inexpensive microwave. The reason for this choice, almost surely, is to avoid the seas off Newfoundland, where cables are likely to be cut by fishing trawlers, with costly interruptions to telephone service. The deepwater route of TAT-3 should be almost immune to cable cutting, and therefore it promises to offer continuous and dependable service.

Some speculation on the future (post-1965) of submarine telephone cables in the Caribbean is in order. In the first place, there is a remote possibility that an overland microwave system will be installed down the length of Central America, from Mexico City to the Canal Zone. We know of no such plans; on the other hand, a microwave system has been or is about to be completed linking Colombia and Ecuador, and another microwave system is being built, 1100 miles long, along the coast of Peru. Under the auspices of the World Bank, a $900,000 study of the telecommunications needs of Central America is about to be launched. In the second place, microwave systems can be used to link islands that are not too far apart. A VHF system for air traffic control, with a capacity of 12 voice channels, was opened June 10, 1960 between Trinidad and St. Thomas in the Virgin Islands, where it connects with an existing microwave system to San Juan, Puerto Rico [BC&E, April 1962, pp. 266-270]. Finally, there is the prospect, especially if political relations with Cuba improve, of linking the various islands in the Caribbean by tropospheric scatter systems.

In summary: HF radio circuits are becoming less and less important as new cable systems are built, but for a long time to come they will provide the only telephone service to very distant points with low traffic density. Service to Europe, the Far East, and Australia will be supplied almost entirely by submarine cables. In North America, additional circuits to Alaska are likely to be furnished by microwave systems rather than by cable systems; service to nearby points in the Caribbean may be supplied by tropospheric scatter circuits rather than by cable circuits; and it remains to be seen whether additional facilities to other points in the Caribbean and

to Central America, beyond those already planned through 1965, will be provided by cable or by a combination of overland microwave, island-hopping microwave, or island-hopping tropospheric scatter.

So far, we have been dealing only with telephone service. Because the telephone cables are suitable for record as well as voice transmission, they also provide alternatives to submarine telegraph circuits and to HF radiotelegraph circuits. The capacity of the submarine telegraph cables and the HF telegraph systems owned by the American international telegraph carriers is even now inconsequential in comparison with the capacity of the submarine telephone cables owned by AT&T, and it will become even less significant in the future. For example, within the past few months, the Commerical Cable Company abandoned its five transatlantic telegraph cables. At the time Commercial Cable applied to the FCC for permission to abandon its cables, Western Union appeared before the FCC to suggest that a favorable action by the FCC on the Commercial Cable proposal be construed as a precedent for favorable action on a similar Western Union proposal, when, and if made [Tel Rpts, 12/26/61, p. 19].

As of September 1962, about half the capacity used by the American international telegraph carriers was capacity in submarine telephone cables (and in telephone tropospheric scatter systems) rented from the various telephone companies. In the few months since September, the telegraph carriers have leased more telephone channels for telegraphic use. It is very likely that within the near future, overseas telegraph communications will be carried almost entirely over telephone systems.

III. THE DEMAND FOR SUBMARINE TELEPHONE CABLE SERVICE

The volume of overseas telecommunications is often credited with a "normal" rate of increase of 11 per cent per year. While this is a very high rate of increase, in comparison with the rates of increase of the outputs of other goods and services, it fails by a wide mark to match the growth of facilities in the next few years. As we have shown in Section I, the capacity of submarine telephone cable systems, whether measured by voice channels or by voice trunks, will nearly triple between the end of 1962 and the end of 1965.

This comparison suggests a temporary overcapacity in the next few years, at the existing telephone rates. This hypothesis is supported by some recent Canadian actions. In November 1961, the rate for calls from Canada to the United Kingdom was reduced from $12.00 to $9.00; night and Sunday rates were reduced from $9.00 to $6.75. (No similar action was required on the British end, because the standard rate for calls from Britain to Canada and elsewhere has been 3 pounds sterling, or $8.40 at the current rate of exchange, for many years.) In July 1962, "substantial reductions" in charges for leased voice channels between Montreal and London, via the Cantat cable, were put into effect. The reductions appear to be in the neighborhood of 30 per cent. [Tel Rpts, 9/18/61, p. 19; 11/6/61, pp. 5-6; 1/8/62, p. 14; 5/21/62, pp. 6-7.] One consequence is that United States international telegraph carriers have quickly leased 10 voice channels in the Cantat cable; they can reach Montreal by paying the $835 a month charged for a leased voice channel between New York and Montreal [Tel Rpts, 11/20/61, p. 12].

On the American side of the border, the hypothesis of temporary overcapacity is less easily sustained. Military demands promise to absorb a sizeable share of the increase in cable capacity, and many of the existing circuits are badly overloaded.

From the start, or almost from the start, military demands have had an effect on the timing of the American submarine cable facilities. The first long-distance submarine telephone cable, to England, was almost certainly in the main a venture designed to satisfy

civilian demands. However, both the second and the third cables were ones in which the military had an interest. The second cable, the Alaska cable, was placed in 1956, from Port Angeles, Washington, to Ketchikan, Alaska, where the cable was linked with the facilities of the Alaska Communications System, at the time a branch of the U.S. Army Signal Corps which furnished long-distance communications throughout Alaska [BTM, Summer 1956, p. 86]. The Dew Line, underway since 1952, was then nearing completion. As for the third cable, the Hawaii cable, it is said that "with military interests in view the completion of this cable was advanced by several years at the request of the U.S. Government" [BTM, Autumn 1957, p. 43].

More recently, military demands have played a major role. Of all the cables AT&T plans to place in the three years 1963-1965, only one at best seems to be timed, routed, and designed to meet primarily civilian demand.

The timing of many of the present AT&T cable projects has been influenced by government requirements set forth as early as 1959. The following excerpts from a letter from AT&T to the FCC are relevant:

> The U.S. Government, through the Air Force, has requested the American Telephone & Telegraph Co., to provide communication channels, using present and proposed transatlantic cable facilities, from points in the United States to points in the United Kingdom or in other countries served through such cable facilities. (The requirements are given in a letter from the Air Force to the company dated April 2, 1959....) The basic requirement is for broadband channels which may be used as such or which may be subdivided into narrower channels, such subdivision to be entirely under the control of the customer. The Air Force requires that a total of 96 kilocycles bandwidth be available beginning in December 1961 in the form of conventional 2.8-kilocycle channels or in combined bandwidths up to 48 kilocycles.

This quotation is taken from a letter dated April 8, 1959, from J. R. Rae, Chief Engineer, AT&T Long Lines Department, to Mary Jane Morris, Secretary of the FCC. In short, the Air Force was asking for 32 voice channels per cable, or 2/3 of the communications capacity of the first-generation AT&T cables.

More recent information suggests that Department of Defense demands are still in this neighborhood. In its application to the FCC for permission to place the Guam-Okinawa cable, AT&T cites a Defense Department demand for 35 voice channels by 1965 on this link (application filed July 2, 1962). If the Defense Department requires 35 voice channels from Okinawa to Guam, it is not unreasonable to suppose that it requires an equal number from Japan to Guam. This hypothesis is supported by the AT&T estimates of the civilian demand for its 1964 Hawaii-Japan cable, which total to only 54 voice channels in 1970, as compared to the cable capacity of 128 voice channels. (See AT&T application to the FCC for the Hawaii-Japan cable, dated June 16, 1961.)

We have already discussed the route followed by TAT-3, a costly but dependable route. It is not unreasonable to suppose that the route was selected with military requirements in mind. AT&T has estimated a private-line requirement for service to Europe of 75 voice channels by 1963, an increase of 55 channels over the 20 voice channels presently leased for private-line telephone service. (See AT&T application to the FCC for TAT-3, filed December 22, 1960.) All of these 20 channels are leased to the Federal Government. We may assume without risk of serious error that most of the 75 voice channels required by 1963 represent Defense Department demand.

The cable from Jamaica to the Panama Canal Zone is now scheduled for completion by April of 1963, an earlier date than had previously been anticipated. AT&T has said, of this cable: "The proposed cables, in conjunction with the submarine cable now under construction between Florida and Jamaica, will meet the urgent need of the military for more and improved communications between the mainland of the United States and the Panama Canal Zone." (AT&T application to the FCC for the Jamaica-Canal Zone-Colombia cable, dated June 20, 1962.)

In summary: although the capacity of submarine telephone cable systems will nearly triple between the end of 1962 and the end of 1965, an appreciable proportion of the increase in capacity is required to meet military demands and to reduce the overcrowding on

existing cables. With respect to the cable systems in which AT&T has an interest, it is conceivable that, in the over-all picture, capacity will no more than match demand by the end of 1965. It is more likely that additional capacity will be required only on the important North Atlantic route as early as 1965 or 1966, while on other routes, capacity will be sufficient to sustain demand for a number of years beyond 1965.

IV. CONCLUSIONS

The laying of submarine telephone cables is now a booming enterprise. Three new cable-laying vessels are challenging the claim, established since 1946, of HMTS Monarch to be the world's best among cable ships. One of these, which lays claim to being the "world's largest cable-laying vessel," went into service in the fall of 1962; another, which claims to be the "world's fastest cable-laying vessel," underwent sea trials in October; and, finally, in March 1963, the AT&T-owned Long Lines, which is said to be the "world's largest and fastest cable-laying vessel," will be ready to start placing cable. New factories to make submarine cable are being built in the United States, England, and Japan. Western Electric has recently completed a new factory for manufacturing the repeaters required in the second-generation AT&T cables.

Several postwar developments have contributed to this outburst of activity. These are the development of long-lived tubes, the development of deepwater duplex repeaters, the development of lightweight armorless cable, and the development of new terminal equipments specifically designed for use with submarine cables.

Since 1956, the capacity of the AT&T cables has been raised significantly. The initial capacity of the first transatlantic cable was 36 voice channels, with no additional voice trunks. The new AT&T cable has a capacity of 128 voice channels, and, with the addition of three TASI equipments, a capacity of 239 voice trunks. Cost per mile per unit of voice channel capacity has been reduced in the period 1956 to 1963 to only 1/4 of its original amount. Cost per mile per unit of voice trunk capacity has been reduced in the same period to only 1/7 of its original amount.

What of the future? A third-generation AT&T cable, which is now within the state of the art, promises to offer voice channel capacity at about 1/3 of the cost of the second-generation cables. In the main, this improvement is expected because of the substitution of transistors for vacuum tubes in the repeaters. It is the rigid

repeaters that account for a great deal of the cost of present-day cables (see Appendix C), not only because they are themselves expensive but also because they create problems in cable laying. Substantial savings in repeater and associated costs will be realized when vacuum tubes are replaced by transistor components. The power required by transistor components is much less than the power required by tubes; hence repeater spacing can be reduced from the present 20 miles to perhaps as little as 5 miles, and the capacity of the cable enhanced to the point where it could be used to carry television programs. As early as 1958, the Bell Laboratories were developing transistorized repeaters for submarine cables [BTM, Summer 1958, p. 33].

The British Post Office has firm plans to replace the two repeaters on one of its short cables laid in 1948, from England to Belgium, with transistorized repeaters. This work will be carried out in the summer of 1964. The capacity of the cable will be raised from 216 circuits to 420 circuits. Until transistor reliability is fully proved out, the Post Office is not ready to use transistors on cables on long routes [BC&E, October 1962, p. 721].

The future of submarine telephone cables is of course very much clouded by the advent of communications satellite systems. One interesting question is whether established communications satellite systems can compete successfully with established submarine cable systems. In view of the fact that the repair and operating costs of submarine telephone cables are very small, it is not unlikely that service will continue to be furnished over existing cables. If so, cables will be around for a good long time, because they may have an actual service life of 30 to 40 years. However, the question is not of primary importance, in view of the fact that the additions to the demand for telecommunications facilities in, say, the period 1965-1975 are likely to dwarf the demand as of 1965.

The more important question is, then, whether there is any economic reason for the extension of submarine telephone cable systems in an era when they will face the competition of established

communications satellite systems. This question warrants analysis. The two systems might survive side by side, with continued expansion of cable capacity, because each will be found to offer advantages for certain types of service.

Appendix A

SUBMARINE TELEPHONE CABLE CHRONOLOGY

1891	Cable under the English Channel.
1921	First deepwater cable (but without submerged repeaters). Placed between Florida and Cuba. Deepwater is more than 4000 feet; shallow water is less than 1500 feet.
1943	First submerged repeaters (but in shallow water), in a cable between Wales and the Isle of Man [Brockbank, p. 1320].
1946-1950	Development of long-lived vacuum tubes for the repeaters which made long-distance deepwater cables a paying proposition. The life of the vacuum tubes was raised from 5 to 20 years [Brockbank, p. 1320].
1950	First submerged repeater deepwater cable, between Florida and Cuba. A 24-circuit, twin-cable system, with simplex flexible repeaters; the first-generation AT&T system, standard until 1962, but usually with 36 circuits.
1954	British 36-circuit cable from Aberdeen, Scotland, to Bergen, Norway, 306 nautical miles. Laid in relatively shallow water, but used a repeater suitable for deepwater systems. [BC&E, February 1962, p. 111; Brockbank, p. 1320.]
1956	First transatlantic cable (TAT-1) placed in operation September 25, 1956. Two links: a British 60-circuit, 4-kc, single-cable system, duplex repeaters, from Nova Scotia to Clarenville, Newfoundland, 326 nautical miles; and the AT&T first-generation system, 36 4-kc circuits, twin cables, from Clarenville to Oban, Scotland, 2000 nautical miles. [Brockbank, p. 1321; NYT, 3/31/61, p. 29; BC&E, February 1962, p. 111.]

	A British standard 60 4-kc circuit system placed from Sicily to North Africa, via Pantellaria; a distance of 107 nautical miles. [BC&E, February 1962, p. 111.]

	AT&T first-generation cable from Seattle to Ketchican, Alaska, placed in service December 1956 [Donald, p. 115].
1957	AT&T first-generation cable from Point Arena, California, to Hawaii placed in service October 8, 1957. 2100 nautical miles. [BTM, Autumn 1957, p. 42; FCC <u>CCS, 1960</u>, p. 173.]
1959	Second transatlantic cable, TAT-2; two links, as in TAT-1: from Nova Scotia to Clarenville, a British 60-circuit cable; from Clarenville to Penmarch, France, 2200 nautical miles, an AT&T 36-circuit cable. Opened for service September 22, 1959. [BTM, Autumn 1957, pp. 41-42; BC&E, February 1962, p. 111.]

1956-1959 Development of two terminal devices that substantially increase the voice channel capacity and the message carrying capacity of existing (and future) cable systems. The first of these is new channeling equipment, which increases voice channel capacity by one-third, or from 36 to 48 voice channels on the existing transatlantic cables. The second is Time Assignment Speech Interpolation, or TASI, a device that doubles the number of conversations that can be carried over the voice channels to which it is applied.

1960 1100-nautical-mile cable between West Palm Beach, Florida, and San Juan, Puerto Rico, placed in operation January 26, 1960. The terminal equipments included the new channeling equipment, and hence this cable system had a capacity of 48 voice channels from the outset. A joint project of AT&T and the Radio Corporation of Puerto Rico. [Donald, p. 117; BTM, Winter 1959-1960, p. 58; FCC CCS, 1960, p. 173.]

New terminal equipments applied to TAT-1 and TAT-2, increasing voice channel capacity from 36 to 48. First use of TASI in June, on TAT-1. TASI applied to TAT-2 by the Autumn of 1960. As of the Autumn of 1960, new channeling equipment was about to be installed on the Hawaii cable, and TASI was to follow soon thereafter. [BSTJ, July 1962, p. 1441; BTM, Autumn 1960, p. 62.]

Standard British cable, 60 (4-kc) circuit, single-cable system, with duplex repeaters, from England to Sweden, 538 nautical miles. [Brockbank, p. 1321; BC&E, February 1962, p. 111.]

1956-1960 Development of armorless cable, which not only saves weight but also is immune to the twisting and kinking that plagues armored cables. The weight in water of the unarmored cable is about one-fifth that of the armored cable. [Brockbank, p. 1322.] Cantat (see below) uses the armorless cable [BC&E, February 1962, p. 110]. The second-generation AT&T cable is also armorless cable.

1961 Commonwealth cable from Canada to the United Kingdom (called Cantat) placed in service December 19, 1961. One link is from Oban to Corner Brook, Newfoundland, 2050 nautical miles, a standard British cable, with a capacity of 60 4-kc voice channels. [BC&E, February 1962, p. 110; Tel Rpts, 12/26/61, p. 19.] The capacity of this link was increased in December 1962 to 80 3-kc channels [private communication from AT&T Long Lines Dept.]. The second Cantat link is from Corner Brook up the St. Lawrence River to the Canadian mainland, at Grosses Roches on the Gaspé Peninsula, 410 nautical miles, 120 circuits, completed about July 15, 1961. [BC&E, February 1962, p. 110; Tel Rpts, 7/3/61, p. 35.]

1962 British standard cable (80 3-kc circuit capacity) laid between New Jersey and Bermuda, 760 nautical miles. Terminal equipment initially provided is sufficient for only 48 voice channels. We believe this cable was placed in service in January 1962, although no formal announcement was made at the time.

A 24-circuit cable, called Scotice, between Great Britain, the Faroes, and Iceland opened for service January 22, 1962. 694 nautical miles. Of the 24 circuits (3-kc channels), 19 are for public use, and 5 for the use of the International Civil Aviation Organization (ICAO), for air traffic control in the North Atlantic in conjunction with the Canada-Iceland cable (see below). [Tel Rpts, 1/29/62, p. 25: BC&E, March 1962, p. 193; BC&E, February 1962, p. 111.]

Commonwealth cable, the first link in Compac, from Sydney, Australia, to Auckland, New Zealand, placed in service July 9, 1962. Capacity of 60 4-kc or 80 3-kc voice channels. About 1200 nautical miles. [Tel Rpts, 7/9/62, pp. 12-13.]

Canada-Iceland 1700-mile, 24-circuit cable, to be placed in service about November 1, 1962. To be used in part by the ICAO for air traffic control in the North Atlantic--see also the note on Scotice above. [Private communication from AT&T.]

1963 AT&T new cable, the second-generation cable, to be placed in service in March 1963, between Florida and Jamaica, 890 nautical miles. A joint venture with Cable and Wireless, Ltd. [Private communication from AT&T Long Lines Dept.; see also AT&T application to the FCC on this cable, dated December 22, 1960.]

Jamaica cable to be extended to the Panama Canal Zone, 128-voice channel capacity, with service hoped for by April 1963. A joint venture of AT&T and the Radio Corp. of Puerto Rico. [Private communication from the AT&T Long Lines Dept.; see also Tel Rpts, 7/30/62, p. 19.]

The United States Underseas Cable Corp. to lay a 700-mile extension to the Atlantic Missile Range cable communications network, under a $5,000,000 Air Force contract [Tel Rpts, 3/5/62, p. 38]. The USUCC is a subsidiary of Felten & Guilleaume Carlswerk AG, Phelps Dodge Corp., and the Northrop Corp.

Third transatlantic cable, TAT-3, to be placed from New Jersey to England, 3500 nautical miles, 128-voice channels. An AT&T second-generation cable. Jointly owned with the British Post Office. Ready for service in December 1963. [AT&T application to the FCC, dated 12/22/60.]

1963 Cont. Commonwealth cable from Auckland, New Zealand, through Fiji and Hawaii to Vancouver, Canada, to be completed by December 1963. The second and final link in the Compac cable between Australia and Canada. [Tel Rpts, 11/13/61, p. 36; 12/26/61, p. 19; 8/6/62, p. 21; 10/15/62, p. 19.]

1964 Two sections of Seacom, the Southeast Asia Commonwealth cable, to be ready for service about mid-1964. One section will run from Singapore to Jesselton, North Borneo, and the other from Jesselton to Hong Kong. [Tel Rpts, 8/6/62, p. 21.] According to information received from AT&T in January 1963, these sections are now planned for completion in 1965 rather than in 1964.

Installation will begin, with completion expected by July 1964, on a cable between Hawaii and Japan, via Midway, Wake, and Guam. 5500 nautical miles, 128-voice channels. A joint project of AT&T, the Hawaiian Telephone Co., and Kokusai Denshin Denwa Co., Ltd. [Tel Rpts, 10/9/61, p. 14, and 2/19/62, p. 15; AT&T application to the FCC, dated 6/16/61; BTM, Spring 1962, p. 27.]

A second cable from the United States mainland to Hawaii. No authorization yet requested from the FCC.

An AT&T 128-voice channel cable to be placed from the United States mainland to St. Thomas, Virgin Islands, and Puerto Rico, with extension to Venezuela. Firm plans for this cable have been delayed somewhat by a change of administration in Venezuela. The idea for a cable to Venezuela is of long standing; originally, Venezuela was to be reached by an extension of the Jamaica cable. The Virgin Islands-Venezuela link will be a British 80-circuit type cable.

1965 Extension of the Jamaica-Canal Zone cable to Colombia. This cable has been delayed because of a change in administration in Colombia. Originally, it was planned as part of the Jamaica-Canal Zone project (see AT&T application to the FCC, filed 6/20/62). According to the original plans, a British-type cable, with 80-voice channel capacity, was to be laid from the Canal Zone to Colombia, as a joint project of AT&T and the Empresa Nacional de Telecommunicaciones [Tel Rpts, 7/30/62, p. 19].

An AT&T cable will be placed between Guam and the Philippines. In its application to the FCC for the Japan cable (filed 6/16/61), AT&T contemplated the extension of this cable to the Philippines.

1965 Cont. Probably, the Seacom cable linking Australia, New Guinea, North Borneo, Singapore, Malaya, and Hong Kong will be completed. Originally, this cable was not scheduled for completion until 1966 [NYT, 9/9/62, pp. 1F and 16F].

Note: This chronology is intended to be complete through 1965, with respect to existing and projected commercial submarine telephone cables with a length of over 500 nautical miles. One possible exception: the Japanese have plans for laying cables, but we do not know the details, nor whether any of their cables will be in service prior to the end of 1965. Aside from the projects of the United States and the various British Commonwealth nations, in association with other nations, we know of only one other fairly major submarine telephone cable system: the French Post Office cable or cables between Marseilles and Algiers.

Appendix B

CAPACITY OF SUBMARINE TELEPHONE CABLES

CAPACITY PER CABLE SYSTEM

The original capacity of the first-generation AT&T cable system, with twin cables, simplex flexible repeaters, was 36 voice channels, each of 4000-cycle, or 4-kilocycle (4-kc) bandwidth.

By 1960, new channeling equipment had been developed and applied. It reduced the bandwidth required per voice channel from 4 to 3 kc, at the expense of an 8 per cent reduction in the top frequency in each channel [McMillan, p. 276]. The improvement could be applied to existing cables because all the new equipment is inserted at the shore-based terminal stations. The effect was to increase the capacity of the cable system from 36 to 48 voice channels.

It may be asked: Why associate improvements in terminal equipments with cables and cable systems? The reason is that the new channeling equipment is not an economical device to apply to overland links; overland, there are less costly means of increasing channel capacity. The new channeling equipment is, therefore, an attribute of a submarine cable system alone.

Occasionally, it has been suggested that for the sake of comparison with other systems, the capacity of submarine cable systems equipped with the new terminal equipments should be expressed in terms of 4-kc channels. Accordingly, for example, the capacity of the first-generation AT&T system would be given as 36 voice channels, even though the new terminal equipment provides a capacity of 48 (3-kc) channels. While this suggestion is right for certain uses of the cable systems, it is against established practice and it is in the main wrong for use of cables for carrying telephone messages. The reason is that the new channeling equipment permits one to obtain the equivalent (subject only to the 8 per cent loss in top frequencies) of four 4-kc channels from 12 kc of spectrum space. Hence, for telephone conversation use, the so-called 3-kc channels of submarine cable systems may be equated with the normal 4-kc channels that one finds overland.

The capacity of the second-generation AT&T cable system, that is going into service in March 1963, is uniformly given as 128 (2.8-kc) voice channels. The second-generation AT&T cable system differs markedly from the first-generation AT&T system; it is single-cable rather than twin-cable, it is unarmored rather than armored, and it uses rigid duplex repeaters rather than flexible simplex repeaters. The total bandwidth of the second-generation cable is about 1000 kc.

The capacity of British deep-sea cables is still expressed both in 4-kc and in 3-kc terms. Although the new channeling equipment is a British development, it is only now being applied to British cables. In 4-kc terms, the British cable system has a capacity of 60 voice channels; in 3-kc terms, it has a capacity of 80 voice channels.

TASI

Time Assignment Speech Interpolation, or TASI, is a device that operates by taking advantage of pauses in conversation to use the temporarily idle channel for other calls. Like the new channeling equipment, TASI was first used in 1960, it can be applied to existing cable systems because it is inserted at the terminal stations only, and it is not an economical device to use with overland systems. It is therefore associated with submarine cable systems alone. The loss in quality of speech transmission due to the use of TASI is not usually noticed by the customer, unless the TASI system is being overworked [BSTJ, July 1962, pp. 1439-1473].

In the circuits to which it is applied, TASI doubles the capacity for carrying telephone conversations. Existing TASI systems, which cost about $3,000,000 each, are applied to a group of 37 voice channels, yielding a total of 74 channels. In times of emergency, TASI systems are overloaded, and may provide as many as 90 channels (from the original 37).

The voice channel capacity of submarine telephone cables is used for (a) ordinary message telephone service; (b) private-line telephone service, restricted to voice only; (c) private-line service for alternate voice and record use, at the discretion of the customer, and (d) telegraph service, over channels leased to the telegraph companies. TASI is ordinarily applied only to channels reserved for message service. It could be applied to private-line channels used for voice only. It is not suitable for application to channels leased to the telegraph companies or for channels leased to others for alternate voice and record use.

No single figure is adequate to express the capacity of TASIed cable systems. Existing practice typically does not differentiate between the voice channels provided by the cable system alone and the voice channels provided by the cable system equipped with TASI. For example, the capacity of TAT-2 (with TASI) is often given as 85 voice channels, although this number is not a relevant number if our interest lies in the use of TAT-2 for, say, the provision of leased circuits to the telegraph companies. In this Memorandum, we have adopted the practice of differentiating between the original <u>voice channel</u> capacity of the cable system and its <u>voice trunk</u> capacity. For example, we describe TAT-2 with TASI as having a capacity of 48 voice channels, or a capacity of 85 voice trunks.

<u>Telegraph Channel Capacity per Voice Circuit</u>

By the use of frequency division channeling equipment, the telegraph companies now normally subdivide each voice channel leased in the telephone cables into 22 telegraph channels.

<u>Other Developments</u>

A number of interesting developments that will greatly increase the information-carrying capacity of communications systems are promised within the next few years. None of these, to our knowledge, are

in the same category as TASI and the new channeling equipment--that is, none of them is especially associated with submarine telephone cables.

CABLE CAPACITY YEAR BY YEAR

Section I of the text presented estimates of the voice channel capacity and the voice trunk capacity of the world's long-distance commercial systems year by year. The detailed capacity data are given in Table 1. AT&T supplied (or verified) the data for the cable systems in which it owns a share. The remaining data may be obtained from the chronology of Appendix A.

A few points need explanation. By June 1961, TASI equipments had been added to all existing AT&T cables, with the exception of the Alaska cable. The actual number of trunks that is added by TASI varies somewhat from cable to cable. On the suggestion of AT&T, we have used the standard nominal figure of 37 trunks added per TASI equipment for each cable system. As for the second-generation AT&T cable, as many as three TASI equipments might be added if there were sufficient demand, and if the circuits were available. However, we assume that at most there will be but one TASI equipment per new cable, and hence at most an addition of 37 voice trunks. The reason is that a large part of the channel capacity of the AT&T cables to be placed to the end of 1965 will be required for military purposes, and hence not subject to augmentation by TASI.

Plans for applying TASI to the British Commonwealth systems have not been announced. However, it is very likely that TASI will be used when required, because it provides a means of doubling the telephone-message carrying capacity of a cable at a cost far less than the cost of building a new cable. We have assumed that by 1965 there will be one TASI equipment per British cable, adding 37 trunks.

Table 1

SUBMARINE TELEPHONE CABLES: VOICE CHANNEL AND VOICE TRUNK CAPACITY, END OF YEAR, 1956-1965[a]

	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965
	A. Cab. 's Originating or Terminating in Canada and the 48 Contiguous States of the United States, Other Than Cables to Cuba[b]									
North Atlantic										
TAT-1	36	36	36	36	48	48	48	48	48	48
TAT-2	0	0	0	36	48	48	48	48	48	48
Cantat	0	0	0	0	0	60	80	80	80	80
Canada-Iceland	0	0	0	0	0	0	24	24	24	24
TAT-3	0	0	0	0	0	0	0	128	128	128
Total voice channels	36	36	36	72	96	156	200	328	328	328
Voice trunks added by TASI	0	0	0	0	74	74	74	74	148	148
Total voice trunks	36	36	36	72	170	230	274	402	476	476
Bermuda (voice channels)	0	0	0	0	0	0	80	80	80	80
Caribbean										
Puerto Rico	0	0	0	0	48	48	48	48	48	48
Jamaica	0	0	0	0	0	0	0	128	128	128
Virgin Islands	0	0	0	0	0	0	0	0	128[c]	128
Total voice channels	0	0	0	0	48	48	48	176	304	304
Voice trunks added by TASI	0	0	0	0	0	37	37	37	74	111
Total voice trunks	0	0	0	0	48	85	85	213	378	415

Table 1 (continued)

	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965
A. Cables Originating or Terminating in Canada and the 48 Contiguous States of the United States, Other Than Cables to Cuba (cont'd)										
Pacific										
Hawaii-1	0	36	36	36	48	48	48	48	48	48
Compac (Canada-Hawaii link)	0	0	0	0	0	0	0	80	80	80
Hawaii-2	0	0	0	0	0	0	0	0	0	128
Total voice channels	0	36	36	36	48	48	48	128	128	256
Voice trunks added by TASI	0	0	0	0	0	37	37	37	74	111
Total voice trunks	0	36	36	36	48	85	85	165	202	367
Total, excluding Alaska:										
Voice channels	36	72	72	108	192	252	376	712	840	968
Voice trunks	36	72	72	108	266	400	524	860	1136	1338
Alaska (voice channels)	36	36	36	36	51	51	51	51	51	51
B. Cables Other Than Those Originating or Terminating in Canada and the 48 Contiguous States of the United States to be Constructed in Whole or in Part by AT&T										
Caribbean (voice channels)										
Jamaica-Canal Zone	0	0	0	0	0	0	0	128	128	128
Canal Zone-Colombia	0	0	0	0	0	0	0	0	0	80
Virgin Islands-Venezuela	0	0	0	0	0	0	0	0	80[c]	80
Pacific (voice channels)										
Hawaii-Guam	0	0	0	0	0	0	0	0	128	128
Guam-Japan	0	0	0	0	0	0	0	0	128	128
Guam-Philippines	0	0	0	0	0	0	0	0	0	128

Table 1 (continued)

	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965
				C. All Other Fairly Major Cables						
Pacific (voice channels)										
Hawaii-New Zealand	0	0	0	0	0	0	0	80	80	80
New Zealand-Australia	0	0	0	0	0	0	80	80	80	80
Singapore-North Borneo-Hong Kong	0	0	0	0	0	0	0	0	0	80
Australia-New Guinea-North Borneo	0	0	0	0	0	0	0	0	0	80
Mediterranean (voice channels)										
Sicily-North Africa	60	-	-	-	-	-	-	-	-	-
Marseilles-Algiers	0	60	-	-	-	-	-	-	-	-
United Kingdom network (voice channels)[d]										
UK-Iceland	0	0	0	0	0	0	24	24	24	24
UK-Sweden	0	0	0	0	60	-	-	-	-	-
UK-Norway	36[e]	-	-	-	-	-	-	-	-	-

Notes:
- We have no information on the voice channel capacity of the cable systems on these routes, other than the initial capacity of the first cable.

[a]Special purpose cables, such as those for the exclusive use of the military forces, are excluded throughout.

[b]With the exception of Cantat, Compac, and the Canada-Iceland cable, all such cables were or are to be constructed in whole or in part by AT&T.

[c]This cable may not be completed until 1965.

[d]Also, cables from the UK to Denmark, Germany, Netherlands, Belgium, and France.

[e]This cable was put in service in 1954.

Appendix C

SUBMARINE TELEPHONE CABLE COSTS

INVESTMENT COSTS PER MILE BY TYPE OF CABLE

The investment costs in which we are interested include the cost of the cable itself, the cost of the repeaters, the cost of engineering and placing the cable, and the cost of the terminal stations. For TAT-3, the estimated costs of these various components are:

3500 nautical miles of cable	$19,000,000 (38%)
192 repeaters	15,000,000 (30%)
Engineering, placing the cable, and other	10,500,000 (21%)
2 terminal stations	5,500,000 (11%)
Total	$50,000,000 (100%)

The cost per repeater implied by these data may be a bit high; according to Western Electric, the cost of the new duplex repeaters is between $60,000 and $70,000 [NYT, 8/16/62, p. 35].

The average investment cost per nautical mile of the second-generation (post-1962) AT&T cables will be about $15,000. This is the average for TAT-3 and the cables from Florida to Jamaica, Hawaii to Japan, and Guam to the Philippines.

The investment cost per nautical mile of the first-generation (pre-1962) AT&T cable systems is in part dependent on the date of construction:

TAT-1	$19,600	1956
Hawaii	16,100	1957
TAT-2	17,600	1959
Puerto Rico	14,500	1960

These data are not entirely comparable with those cited for the second-generation systems, because they include the costs of TASI equipments. A single TASI equipment costs about $3,000,000, and hence adds appreciably to the cost per nautical mile--$1,500 for a 2000-mile system, for example. The estimated costs of the new cable systems do not include TASI costs.

The only British cable for which we have adequate data is the cable from the United States to Bermuda, with an investment cost of $10,000 per nautical mile. This cost is lower than the cost of $15,000 per nautical mile of the second-generation AT&T cable, but not unreasonably so, since the capacity of the British cable is 80/128 the capacity of the American cable.

In summary, the investment cost (including TASI cost) per nautical mile of the first-generation AT&T cable declined from $19,600 in 1956 to $14,500 in 1960; the cost per nautical mile of the second-generation AT&T cable is about $15,000; and the cost per nautical mile of the British cable is about $10,000.

CABLE OPERATING COSTS AND LIFE

For operating, repair and maintenance costs on the second-generation AT&T cables, Long Lines gave RAND an estimate of $300,000 per year per cable system [RM-2778, p. 16]. This is a rock-bottom estimate: it excludes all general overhead and administrative expenses.

Repair costs vary from cable to cable. One variable factor is the frequency of cable breaks. From 1956 to 1961, the North Atlantic telephone cables were broken at a rate of somewhat less than one per year per cable [NYT, 3/31/61, p. 29]; on the other hand, the Hawaii cable has never been broken. According to AT&T estimates, cable breaks can be repaired in 9 hours at a cost of about $50,000; in deep water, the repair cost is $100,000.

We do not include the revenues lost, due to interruptions of service because of cable breaks, as part of operating costs. The loss of revenue can be significant. For example, in the case of one break in a North Atlantic telephone cable, caused by an iceberg, the ice prevented the cable-repair ship from reaching the site of the break for at least a week [NYT, 3/31/61, p. 29]; a week's loss of revenue might amount to $200,000 or more.

Brockbank says that repeater repair, including loss of revenue, amounts to over $560,000 [Brockbank, p. 1322]. It is unlikely that repeater repair is a significant item in the cost of operating the

AT&T cables, since as of early 1962, there had been no failures whatsoever in the submarine cable vacuum tubes, some of which had been in service for as long as 12 years [BTM, Spring 1962, pp. 63-64].

The life of a cable system is always given as 20 years. This estimate does not refer, we believe, to the cable itself. There are telegraph cables that have been in service for 78 years. The factor limiting cable life is the life of the vacuum tubes in the repeaters. The present belief is that all the existing AT&T tubes may last 20 years [ibid.].

It is possible to replace faulty repeaters and hence to extend the life of the cable system. In fact, the British plan to do this in the next year or two on one of their shorter cables that is laid in shallow water.

TOTAL INVESTMENT IN CABLE SYSTEMS

In Section I, estimates were given of the investment in all commercial cable systems as of the end of 1962 and the end of 1965. The costs of the individual cable systems are given in the attached table, together with data on ownership. Except as noted, AT&T supplied all the information on cables in which it has an interest. For standard British Commonwealth cable systems, we estimate cost by multiplying mileage by $10,000. For the 24-circuit Canada-Iceland and Iceland-UK cables, we estimate cost by multiplying mileage by $5,000. The total cost of $363,000,000 obtained for the period 1963-1965 is probably low; for example, the Japanese have plans for cable systems, some of which may be completed before the end of 1965.

Table 2

SUBMARINE TELEPHONE CABLES: FIRST YEAR OF OPERATION, LENGTH, INVESTMENT COST, AND OWNERSHIP[a]

	First Year of Operation	Length (nautical miles)	Investment Cost (million dollars)	Interests of Parties: Company	Interests of Parties: Per Cent
				A. Cables Put in Service Prior to December 31, 1962	
North Atlantic					
TAT-1 (Sydney Mines, Nova Scotia to Oban, Scotland)	1956	2300	45.0	AT&T	41[b]
				British Post Office	50[b]
				Canadian Overseas Tel. Corp.	9[b]
TAT-2 (Sydney Mines to Penmarch, France)	1959	2500	44.0	AT&T	56.2[c]
				France	17.7
				Germany	17.7
				Switzerland	2.6
				Belgium	1.6
				Netherlands	1.6
				Italy	2.6
Cantat (Grosses Roches, Canada to Oban)	1961	2500	25.0**	British Commonwealth cable	
Canada-Iceland	1962	1700	8.5**	Unknown	
Bermuda (Manahawkin, N.J. to Bermuda)	1962	760	9.4	AT&T	46.9
				Cable & Wirless, Ltd.	50.0
				Canadian Overseas Tel. Corp.	3.1
Puerto Rico (West Palm Beach, Fla. to San Juan)	1960	1100	16.0	AT&T	50
				Radio Corp. of Puerto Rico	50
Hawaii-1 (Point Arena, Calif. to Oahu)	1957	2200	35.5	AT&T	65
				Hawaiian Telephone Co.	35
Australia-New Zealand (Sydney to Auckland)	1962	1200**	12.0**	British Commonwealth cable	
Alaska (Port Angeles, Wash. to Ketchikan)	1956	750	15.8	AT&T	100

Table 2 (continued)

	First Year of Operation	Length (nautical miles)	Investment Cost (million dollars)	Interests of Parties: Company	Per Cent
			A. Cables Put in Service Prior to December 31, 1962 (cont'd)		
UK-Sweden	1960	538	5.4**	Unknown	
UK-Iceland	1962	694	3.5**	British Post Office	Unknown
				Great Northern Telegraph Co. of Denmark	
				Danish Ministry of Post Telegraph and Telephone	
				Icelandic Ministry of Post Telegraph and Telephone	
Total			218.3		
			B. Cables to be Put in Service, 1963-1965		
TAT-3 (Manahawkin, N.J. to Widemouth, England)	1963	3500	50.0*	AT&T	50
				British Post Office	50
Caribbean					
Jamaica (Florida City, Fla. to Kingston)	1963	890	13.5*	AT&T	75
				Cable & Wireless, Ltd.	25
Jamaica-Canal Zone	1963	960	13.0*	AT&T	58
Canal Zone-Colombia	1965			Radio Corp. of Puerto Rico	32
				Empresa Nacional de Telecommunicaciones	10
Florida-Virgin Islands-Venezuela	1964 or 1965	1900	26.0*	AT&T	Unknown
				Radio Corp. of Puerto Rico	Unknown
				Venezuela	Unknown

Table 2 (continued)

	First Year of Operation	Length (nautical miles)	Investment Cost (million dollars)	Interests of Parties	
				Company	Per Cent
		B. Cables to be Put in Service, 1963-1964			
Pacific					
Hawaii-Japan (via Midway, Wake, and Guam)	1964	5500	84.0*	AT&T	54.3
				Hawaiian Telephone Co.	8.4
				Kokusai Denshin Denwa Co., Ltd.	37.3
Vancouver, B.C. - Hawaii-Fiji-Auckland, New Zealand	1963	6400**	64.0**	British Commonwealth Cable	
Seacom (Australia-New Guinea-North Borneo, Singapore, Malaya, Hong Kong)	1965	6000**	60.0**	British Commonwealth Cable	
Hawaii-2 (Calif.-Hawaii)	1965	2100	31.5**	AT&T and Hawaiian Telephone Co.	
Guam-Philippines	1965	1450	21.0*	AT&T and others	
Total			363.0		

Notes:

*AT&T estimate.

**RAND estimate.

[a]Restricted to cable systems offering service to the general public of length greater than 500 nautical miles.

[b]AT&T owns 50 per cent of this cable, although it contributed only 41 per cent of the investment costs.

[c]When all of the circuits reserved in this cable for other European countries have been taken up, AT&T's ownership of this cable will fall to 50 per cent.

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